REMARKS/ARGUMENTS

Claims 1-52 are pending in this application, with claims 1-33 previously withdrawn from consideration. Claims 34-52 are hereby rejected. Claims 34, 38, 45 and 48 are amended on this paper.

Applicants respectfully believe that claims 34-52 are distinguished from the references of record and respectfully request allowance of each of claims 34-52 based upon the remarks set forth below.

On page 2 of the Office Action, claims 34-52 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Lin (USPN 6,093,656) in view of Jang (USPN 6,350,364) and further in view of Sugai (USPN 6,569,756). Applicants respectfully submit that claims 34-52 are distinguished from these references of record for the following reasons.

Independent claims 34 and 45 each recite the feature of a copper interconnect structure with a first copper layer and a second copper layer each formed in the same opening. The second copper layer is disposed over the first copper layer and each of the first and second copper layers have vertical sidewalls that extend along *the same side of the opening*. The first and second copper layers have grain densities of G_{D1} and G_{D2}, respectively. In particular, independent claim 34 recites:

> "a first copper layer having first substantially vertical sidewalls . . . formed in an opening . . . said first substantially vertical sidewalls disposed along sides of said opening"; and
>
> "a second copper layer disposed **in** said opening and having second substantially vertical sidewalls disposed along **said** sides of **said** opening, a substantially planar top surface that is about coplanar with the top of said dielectric layer and a convex bottom surface that forms an interface with said concave top surface of said first copper layer."

Clearly, the second copper layer is disposed above the first copper layer and *in the same opening*. Each of the first and second copper layers has vertical sidewalls that extend along *the same sides* of the same opening.

Independent claim 45 similarly recites:

> "a first copper layer . . . having . . . first substantially vertical sidewalls that are disposed along said trench sidewalls"; and
>
> a second copper layer formed within . . . **said** opening and having second substantially vertical sidewalls that are disposed along **said** trench sidewalls a substantially planar top surface that is about coplanar with the top of the dielectric layer . . . and a convex bottom surface that forms an interface with the concave top surface of said first copper layer.

Claim 34 therefore also recites two copper structures in the same trench opening formed in a dielectric. The copper layers are formed one over another and each have substantially vertical sidewalls that extend along *the same sidewalls of the trench opening*.

Neither of the references teach or suggest these features. Claims 34 and 45 recite a combination of limitations, some of which separately may be known. It is this new combination of these limitations which is claimed and which is non-obvious under the conditions of 35 U.S.C. § 103. Applicants respectfully submit that the Examiner has improperly attempted to establish obviousness by locating references which describe various aspects of Applicants' invention without providing evidence of any motivating force which would impel one skilled in the art to do what the Applicants have done. The Examiner has rejected the claims using hindsight reconstruction gleaned from the Applicant's claimed invention itself.

Moreover, as will be pointed out below, each of amended independent claims 34 and 45 include significant limitations other than known limitations. Therefore, even if

one were to combine the teachings of the references of record, the combination falls short of the distinguishing claimed features, as described below.

As above, neither the Lin nor Jang references disclose the features of having a copper interconnect structure formed of two copper layers formed over one another within the same opening and having vertical sidewalls along the same sides of the opening: As conceded by the Examiner on page 2, fifth paragraph, Lin does not disclose a second copper layer, much less one in the same opening. Jang discloses first and second copper layers but not in the same opening.

If one combined the references in the manner suggested by the Examiner, the claimed invention would not result. In particular, if the second copper formation step of Jang were performed after the first copper layer of Lin was formed as suggested in the subject Office Action, p. 3, second paragraph, the combination would fall short of the claimed invention because the first copper layer 20 of Lin is formed within opening 14 formed in dielectric layer 11 but there is no area within opening 14 for which another copper film to be disposed. An examination of FIGS. 2-6 of Lin show that copper film 20 fills opening 14 and extends above opening 14 until FIG. 6 where it is finally made to be coplanar with the upper surface of dielectric layer 11. There is no room in opening 14 to receive any more copper. The subsequent deposition of the upper copper film of Jang would not fulfill the claimed limitations of being "in" *said* opening, "said" referring back to the same opening 14 in which first copper layer 20 is formed. Moreover, an upper copper film formed over any of FIGS. 2-6 of Lin could not meet the claim limitation of having a vertical sidewall disposed along the same side/sidewall of the same opening, i.e., "in said" opening, as the lower copper film 20 of Lin because there are no exposed sides of opening 14. Rather copper layer 20 fills opening 14 at all times.

Moreover, even if one looked at the prior art FIG. 1 of Lin, in which the copper film 16 includes a concave upper surface 18 due to dishing, any superjacent copper film could not satisfy the claimed limitations of having vertical sidewalls disposed along the sidewalls of the same opening as does lower copper film 16. This is so because the

curved upper surface 18 peripherally extends to the top surface of the dielectric layer 6, leaving no exposed sides/sidewalls of the opening and along which a superjacent film could be disposed.

Therefore, independent claims 34 and 45 are distinguished from the Lin and Jang references, taken alone or in combination.

The Sugai reference has been apparently relied upon for providing copper layers with different grain densities and does not make up for the above stated deficiencies of the combination of Lin and Jang. In particular, Sugai, like Lin and Jang, does not disclose or suggest the aforementioned claimed features of the second, upper copper layer formed in the same opening and having vertical sidewalls that extend along the same sides of the opening in which each of the two copper films are formed.

Claims 34 and 45 are therefore distinguished from the references of Lin, Jang and Sugai, taken alone or in combination.

Moreover, Applicants respectfully submit that it is not inherent nor is it disclosed in Sugai, that copper films made by different methods and conditions have different grain densities. Grain density of a formed copper film depends on many factors including conditions of formation and subsequent treatment(s). The first copper film of Sugai is formed by CVD and is later reflowed. The second copper film in Sugai is formed by sputtering. Since many factors combine to determine the grain density of a copper film, the Examiner has not established that the two copper films in Sugai necessarily have different same grain densities. For example, each of the copper films could have the same grain density, e.g., each being G_{D1} (or G_{D2}).

Claims 34 and 45 are therefore distinguished from the references of Lin, Jang and Sugai, taken alone or in combination and therefore the rejection of these claims under 35 U.S.C. § 103(a), should be withdrawn. Claims 35-44 depend, directly or indirectly, from amended independent claim 34 and claims 46-52 depend, directly or indirectly, from amended independent claim 45 and each of these claims is therefore

distinguished from the references of record. As such, the rejection of each of claims 34-52 under 35 U.S.C. § 103(a), should be withdrawn.

CONCLUSION

Based on the foregoing, each of pending claims 34-52 is in allowable form and the application in condition for allowance, which action is respectfully and expeditiously requested.

The Assistant Commissioner for Patents is hereby authorized to charge any fees or credit any excess payment that may be associated with this communication to Deposit Account 04-1679.

Respectfully submitted,

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